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Description

The pres nt invention relates t a film thickness measuring instrument and, mor particularly, to an instrument for m asuring a thickness of a surface film which was coated on a metal plate.

Generally, a thickness of a painted film, plated film or aluminate film which is coated on a metal for the purpose of anti-corrosion, insulation or good outside appearance lies within a wide range from a few micrometers to hundreds of micrometers. As an instrument for measuring this thickness without hurting the film, there is an eddy-current instrument for measuring film thickness in which a high frequency electromagnetic field affected by what is called an eddy current loss which is caused in a metal due to the applied high frequency electromagnetic field that is generated from the primary winding wound around a core of a probe which was pressed on the film is measured by the secondary winding wound around that probe, then the high frequency electromagnetic field is converted into the film thickness and is displayed. On the other hand, when the metal is the iron based system having a high permeability, the electromagnetic inductive coupling between the probe and the metal becomes strong, so that it is advantageous to constitute a measuring circuit. Such a measuring instrument is known as an electromagnetic instrument for measuring thickness. The invention can be commonly applied to both instruments for measuring thickness of the above-mentioned types.

As the request for quality of the surface processing film on the metal becomes severe, there is demanded an instrument for measuring thickness which can more promptly perform the measurement of film thickness at various locations and can obtain the higher arithmetic operation result.

At a construction field such as a bridge, steel tower, high-rise building, etc., when a film thickness is measured using a conventional thickness measuring instrument in order to see if the thickness lies within a reference range or not, the work such that the displayed value regarding the thickness which is read out by a measuring person who climbs the measuring location is recorded by another recording person is repeatedly executed with respect to each measuring point. This record data is input to a computing apparatus or the like, so that the mean value is obtained or a discrimination is made to see if it lies within the reference range of thickness or not. It is very dangerous for the measuring person himself to record the measured data and carry out the arithmetic operation to obtain the mean value at the above-mentioned construction field.

It is th refore an obj ct of the present invention to provide an instrument for measuring film thickness which can record the data to be measured in a print r built therein and can present a simple measuring operation at a dangerous location.

Another object of the invention is to provide an instrument for measuring film thickness which can c mpletely perform th continuous measur ment and recording by a s le person at a measuring location.

According to the present invention there is provided a portable electromagnetic thickness measuring instrument to measure the thickness of a surface film on metal, comprising:

a plurality of instruction means on a front face of the instrument;

a terminal for connecting a probe to detect an electric signal corresponding to the film thickness D, being the distance between the probe and the metal when the probe is pressed against the film;

a converting circuit for converting the detected electrical signal to a digital value indicative of film thickness D;

a power source for supplying a voltage to the converting circuit; characterised by:

a plurality of instruction keys constituting the instruction means;

a digital data processing apparatus operable in accordance with instructions entered by operation of the keys

— to connect the power source to the converting circuit for a predetermined time period after depression of the appropriate key,

— to receive digital values from the converting circuit,

— to perform arithmetic operations on the digital values in accordance with the instructions given by depression of the keys,

— to count the number of measurements during the predetermined time period,

— to calculate the mean value of the values measured during the predetermined time period, and the standard deviation of the values measured during the predetermined time period,

— to compare the digital values with a stored calibration curve of values of thickness, and

— to automatically output, when the measurement count reaches a preset number, said mean value of the measured values, the number of measurement times, standard deviation, and measurement number; and

a thickness recording apparatus for recording the output of said processing apparatus.

Preferably, the instrument comprises a threshold circuit in the converting circuit to detect when the probe is within a predetermined distance of the metal, as determined by the thickness D of the film, and a holding circuit to hold the digital value corresponding to the minimum value of the distance between the probe and the metal.

Preferably, in response to the number of pressing operations of the probe reaching a predetermined number input preliminarily, the mean valu and standard deviation of the values is calculated and output to said recording apparatus.

EP—A—0028487 discloses a thickness measuring instrument comprising all the technical features r ferred to in th preamble of the present claim 1.

Fr m EP—A—0094054, a portabl measuring instrument is known having a plurality of instruction keys and a digital data proc ssing apparatus operable in accordance with instructions entered by op ration of the keys, and performing arithmetic perations on the digital values in accordance with the instructions given by depression of the keys.

US—A—3808525 shows and describes thickness measuring device for indicating the mean value of a reset number of measurements of the thickness of a layer. This device uses a counter for counting the number of measurements during a predetermined time period.

The use of recording apparatuses within portable devices, and the connection of a power source to a specific circuit for a predetermined time period after depression of a key, are generally known.

The present invention will be apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:—

Figure 1 illustrates a principle diagram;

Figure 2 shows a current change diagram;

Figure 3 is a block circuit diagram;

Figure 4 illustrates an external view; and

Figures 5 to 7 show flow charts for explaining the operation.

Figure 1 is a diagram for explaining a principle of the measurement, in which a current I is flowing from an AC power source 4 through a probe 3 which is constituted by an iron core 1 around which a coil 2 is wound.

As the probe 3 approaches an iron material 6 whose surface is coated by a film 5, this current changes as shown in Figure 2. If a calibration curve of the current change is prepared using a standard plate which has the same material as the iron material 6 and on which a film having a predetermined thickness has been preliminarily coated on the basis of the well-known electromagnetic induction rule, a film thickness D can be known by obtaining the current change which is actually measured.

Figure 3 shows a diagram of a block circuit to realize the foregoing measurement. A sensor circuit 11 includes the AC power source 4, a circuit to detect the current change ΔI and AD converter for converting the detected current change to the digital value. This digital value is input to a microcomputer 13 having well-known RAM and ROM and is converted to the thickness value of the film 5 on the basis of the data on the calibration curve stored in the ROM. This thickness value is sent to a display circuit 18 and displayed, or it is sent to a printer 15 and printed. Although a general power source 16 supplies a power source current to these circuit elements, an analog power source 12 is connected to supply a voltage having a less fluctuation to the sensor circuit 11. A d tailed constitution of instruction executing keys 14 is written in a key arrang ment 19 in an external vi w shown in Fig. 4.

Fig. 5 shows a flow chart for explaining the operation to determine the calibration curve using two standard plates prior to the actual measurement. When a CAL key in Fig. 4 is pressed, an interruption signal is input to the microcomputer 13, so that the operation of a program shown in this flow chart is start d. The probe is pressed onto the standard plate which is not subjected to the film process, that is, the plate having a film thickness of D=0. The minimum value corresponding to point C_1 (Fig. 2) after the current change ΔI shown in Fig. 2 became a value below a certain threshold value ΔI_0 is held in the sensor circuit 11 and stored in an RAM (not shown). (51 in Fig. 5). Next, the data corresponding to point C_2 is similarly stored by use of the standard plate having a film thickness of D=200 µm. (52 in Fig. 5). A parameter of the quadratic equation indicative of the calibration curve 21 shown in Fig. 2 is determined on the basis of data at those two points and a preparation to calculate the measurement film thickness corresponding to the current change ΔI after that is completed. (53 in Fig. 5).

Fig. 6 shows a main program which is started when a power switch of the film thickness measuring instrument of the invention, i.e., a RESET key 20 is turned on. This main program is stored in an ROM in the microcomputer 13. In the case where a measurement is not performed for five minutes or longer after the turn-on of the power switch, a timer in the microcomputer 13 is set to five minutes in block 61 in order to automatically disconnect the analog power source 12 for saving energy. Block 63 indicates the voltage drop checking or alarming operation of a battery, i.e., the general power source 16 that is executed in such a standby mode.

The process routine skips the above-mentioned loop when the probe 3 is used for measurement, namely, when the current change ΔI becomes smaller than the threshold value ΔI_0 and advances from discriminating block 62 to block 64, thereby cancelling the time counting operation of the five-minute timer. In other words, it is assumed in this measuring instrument that the single measuring operation is carried out in a sufficiently shorter time than five minutes. The measured value is expressed by a predetermined unit of µm (or mil) (block 65) and is output to the display circuit 18 or printer 15 (block 66). The display content is indicated in a display 34 which is located at the central portion of the external view in Fig. 4.

After that, the foregoing procedure is repeated and the measurement is continued.

According to the film thickness inspection specifications at many measuring fields, the measurement is executed by predetermined times at every measuring points. Therefore, it is possible to preliminarily designate by the key arrangement 19 in a mann r such that the number of measur ment times is preset and wh n it r ach s th pr s t value, the mean value of the measured valu s, number of measurement times, standard deviation, data, and measurement number are automatically output.

The proc dure to set the dat among various designating pr cedures will be explained with reference to Fig. 7.

When a FUN key 26 is pr ssed, the operation shown in Fig. 6 is interrupted. A pr gram in Fig. 7 is started by pressing a doubl defining key 27 to designate a numeral 7 and function (date=DATE) (block 71). The data is input by a ten-key 28 (block 72). Depressing an ENT key 29 causes the designating operation to be finished (block 73).

Due to the above designating operations, there is no need at all for the measuring person to input any key after the measuring operation started. Namely, the operation of the program shown in Fig. 6 is started by merely pressing the probe onto a measuring point and the measurement result is automatically output; therefore, it is enough for the measuring person to merely observe the output value. Other terms different from the above-mentioned terms can be further added or eliminated as the measurement output terms of the thickness measuring instrument according to the invention.

On one hand, although the timer has been set at five minutes, the designer may freely set the timer to a different time.

Although Fig. 2 shows a curve 22 regarding material A and a curve 21 with respect to material B, the number of kinds of different materials is not limited. In addition, a trouble with regard to the measuring operation is eliminated by separately providing the power source for operation of the printer 15 and the battery of the general power source 16.

A PRINTER ON/OFF key 30 is used when the printer output is unnecessary.

A DEL key 31 is used to erase the value which was erroneously measured.

An F.R. key 32 is used when a mean value A_n,

$$A_n = \frac{1}{n} \sum_{j=1}^{n} X_j \qquad (1)$$

of the measurement values which were measured so far and a standard deviation s,

$$s = \sqrt{\frac{1}{n-1} \left\{ \sum_{j=1}^{n} X_j^2 - \frac{1}{n} \left(\sum_{j=1}^{n} X_j \right)^2 \right\}} \qquad (2)$$

are output irrespective of a predetermined number of times.

The thickness measuring instrument of the invention is equipped with the small-sized printer 15 therein and has a shape as shown in the external view of Fig. 4, so that it can be easily put in a pocket of a cloth. The probe 3 can be pulled out from a terminal 10 and another kind of probe may be used.

When a PAPER FEED k y 33 is pressed, a print paper is fed out from a concave portion 36 and the printed portion of the print paper can be cut out using a saw blade 35.

Claims

1. A portable electromagnetic thickness measuring instrument to measure the thickness of a surface film (5) on metal (6) comprising:

a plurality of instruction means on a front face of the instrument;

a terminal (10) for connecting a probe (3) to detect an electric signal corresponding to the film thickness D, being the distance between the probe (3) and the metal (6) when the probe (3) is pressed against the film (5);

a converting circuit (11) for converting the detected electrical signal to a digital value indicative of film thickness D;

a power source (12) for supplying a voltage to the converting circuit (11); characterised by:

a plurality of instruction keys (14) constituting the instruction means;

a digital data processing apparatus (13) operable in accordance with instructions entered by operation of the keys (14)

— to connect the power source (12) to the converting circuit (11) for a predetermined time period after depression of the appropriate key,

— to receive digital values from the converting circuit (11),

— to perform arithmetic operations on the digital values in accordance with the instructions given by depression of the keys (14),

— to count the number of measurements during the predetermined time period,

— to calculate the mean value of the values measured during the predetermined time period, and the standard deviation of the values measured during the predetermined time period,

— to compare the digital values with a stored calibration curve of values of thickness, and

— to automatically output, when the measurement count reaches a preset number, said mean value of the measured values, the number of measurement times, standard deviation, and measurement number; and

a thickness recording apparatus (15) for recording the output of said processing apparatus (13).

2. An instrument as claimed in claim 1, characterised by:

a threshold circuit in the converting circuit (11) to detect when the probe (3) is within a predetermined distance of the metal (6), as determined by the thickness D of the film (5), and a holding circuit to hold the digital value corresponding to the minimum value of the distance between the probe (3) and the metal (6).

3. An instrument as claimed in claim 2, characterised in that in response to the number of pressing operations of the probe (3) reaching a predetermined number input preliminarily, the mean valu and standard deviation of the values is calculated and output to said recording apparatus (15).

Patentansprüch

1. Tragbares el ktromagnetisches Dickenmeßgerät für die Messung der Dicke eines Oberfläch nfilms (5) auf einem Metall (6), mit:

einer Vielzahl von Instruktionseinrichtungen an einer Frontseite des Gerätes;

einem Terminal (10) zur Verbindung mit einer Sonde (3) für die Ermittlung eines elektrischen Signals entsprechend der Filmdicke D, die gleich dem Abstand zwischen der Sonde (3) und dem Metall (6) ist, wenn die Sonde (3) gegen den Film (5) gepreßt wird;

einem Wandlerschaltkreis (11) für die Umwandlung des elektrischen Signals in einen die Filmdicke D anzeigenden digitalen Wert;

eine Spannungsversorgungseinrichtung (12) für die Versorgung des Wandlerschaltkreises (11) mit einer Spannung; gekennzeichnet durch:

eine Vielzahl von Instruktionstasten (14), die die Instruktionseinrichtung bilden;

eine digitale, datenverarbeitende Vorrichtung (13), die entsprechend den durch Betätigung der Tasten (14) eingegebenen Instruktionen arbeitet,

— um die Spannungsversorgungseinrichtung (12) mit dem Wandlerschaltkreis (11) über eine vorbestimmte Zeitperiode nach dem Drücken der geeigneten Taste zu verbinden,

— um digitale Werte von dem Wandlerschaltkreis (11) zu empfangen,

— um arithmetische Operationen mit den digitalen Werten entsprechend den Instruktionen, die durch Drücken der Tasten (14) eingegeben wurden, auszuführen,

— um die Anzahl von Messungen während der vorbestimmten Zeitperiode zu zählen,

— um den mittleren Wert der während der vorbestimmten Zeitperiode gemessenen Werte zu bestimmen und die Standardabweichung der während der vorbestimmten Zeitperiode gemessenen Werte zu berechnen,

— um die digitalen Werte mit einer gespeicherten Kalibrierkurve aus Dickenwerten zu vergleichen,

— um automatisch, wenn die Messungszählung einen voreingestellten Werte erreicht, den Mittelwert der gemessenen Werte, die Anzahl der Messungszeiten, die Standardabweichung und die Messungsanzahl auszugeben; und

eine Aufzeichnungsvorrichtung (15) für die Aufzeichnung der Ausgabe der Verarbeitungsvorrichtung (13).

2. Gerät nach Anspruch 1, gekennzeichnet durch: einen Schwellenwertschaltkreis in dem Wandlerschaltkreis (11), der anspricht, wenn sich der Fühler (3) innerhalb einer vorbestimmten Distanz zu dem Metall (6), wie sie durch die Dicke D des Films (5) bestimmt ist, befindet, und einen Halteschaltkreis, der den digitalen Wert festhält, der dem minimalen Wert der Distanz zwischen der Sonde (3) und dem Metall (6) entspricht.

3. Gerät nach Anspruch 2, dadurch gekennzeichnet, daß in Reaktion auf die Anzahl d r Anpreßoperati nen der S nd (3), die eine vorbestimmte, vorher eingegebene Zahl err icht, der Mittelwert und die Standardabweichung der W rte ber chnet und an die Aufzeichnungsvorrichtung (15) ausgegeben wird.

Revendications

1. Un instrument électromagnétique portable de mesure d'épaisseur, pour mesurer l'épaisseur d'un film de surface (5) sur un métal (6), comprenant:

une pluralité de moyens d'instruction sur une face avant de l'instrument;

une borne (10) pour le branchement d'un capteur (3) pour détecter un signal électrique correspondant à l'épaisseur D du film, qui est la distance entre le capteur (3) et le métal (6) lorsque le capteur (3) est pressé contre le film (5);

un circuit de conversion (11) pour convertir le signal électrique détecté en une valeur numérique indicative de l'épaisseur D du film;

une alimentation électrique (12) pour alimenter le circuit de conversion (1) en énergie; caractérisé par

une pluralité de touches d'instruction (14) constituant les moyens d'instruction;

un appareil de traitement de données numérique (13) fonctionnant en fonction des instructions entrées par l'intermédiaire des touches (14);

le branchement de l'alimentation électrique (12) au circuit de conversion (11) pendant une période de temps prédéterminée après que la touche appropriée a été relâchée;

la réception des valeurs numériques provenant du circuit de conversion (11);

le calcul des opérations arithmétiques sur les valeurs numériques, en fonction des instructions données par le relâchement des touches (14),

le décompte du nombre de mesures effectuées pendant la période de temps prédéterminée;

le calcul de la valeur moyenne parmi les valeurs mesurées pendant la période de temps prédéterminée, et la déviation normale des valeurs mesurées pendant la période de temps prédéterminée;

la comparaison des valeurs numériques avec un enregistrement d'une courbe de calibrage des valeurs d'épaisseur; et

la sortie automatique, lorsque le décompose de la mesure atteint un nombre prédéfini, de ladite valeur moyenne parmi les valeurs mesurées, du nombre de moments de mesure, de la déviation normale, et du nombre de mesures; et

un appareil d'enregistrement d'épaisseur (15) pour enregistrer la sortie dudit appareil de traitement (13).

2. Un instrument tel que revendiqué à la revendication 1, caractérisé par:

un circuit de seuil dans le circuit de conversion (11) pour détecter le moment où le capteur (3) se trouve à une distanc prédéterminée du métal (6), tel que déterminé par l'épaisseur D du film (5), t un circuit d mainti n pour maintenir la val ur numériqu corr sp ndant à la valeur minimale de la distance entre le capteur (3) et le métal (6).

3. Un instrum nt t l qu revendique à la revendication 2, caractérisé en ce que, en réponse au

nombre d'opérations de pression du capteur (3) atteignant un nombre prédét rmin´ entré au préalable, la valeur moyenne et la déviation normale des valeurs sont calculées et transmis s audit appareil d'enregistrement (15).

FIG. 1

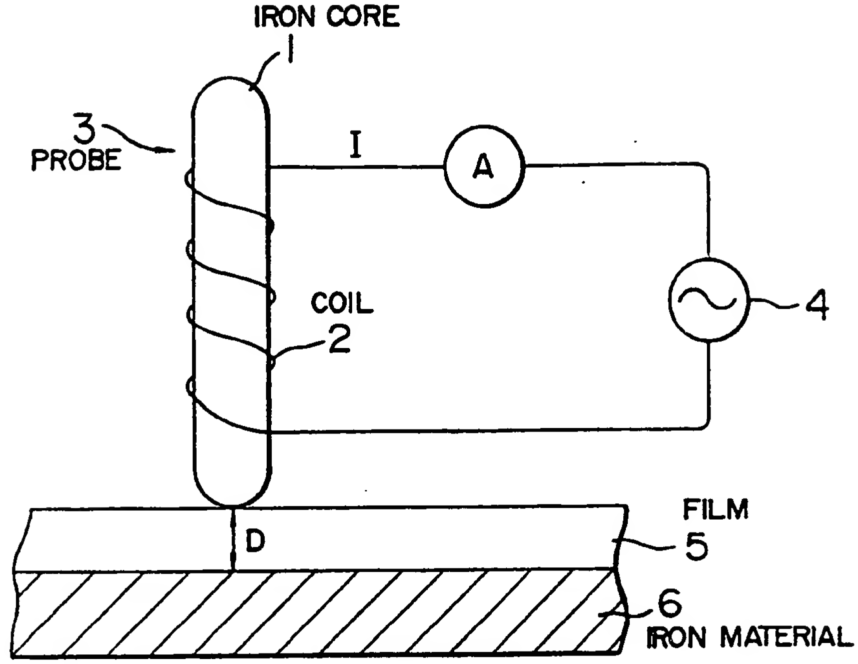
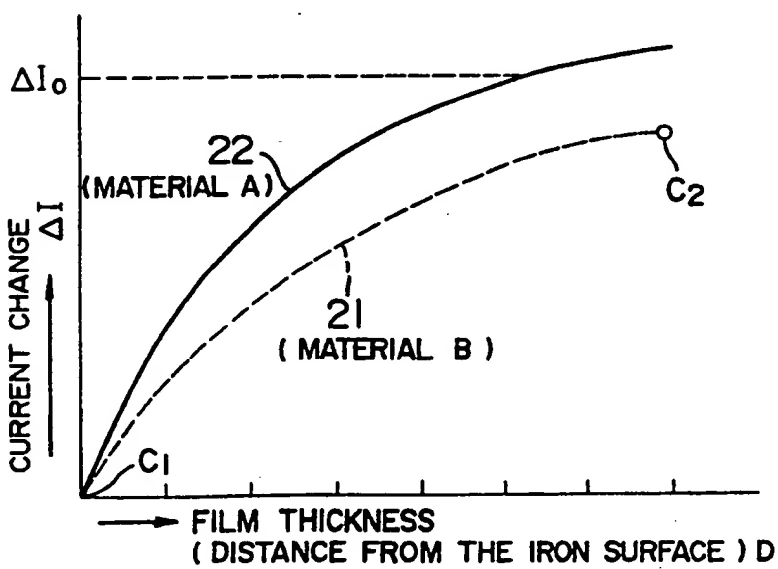
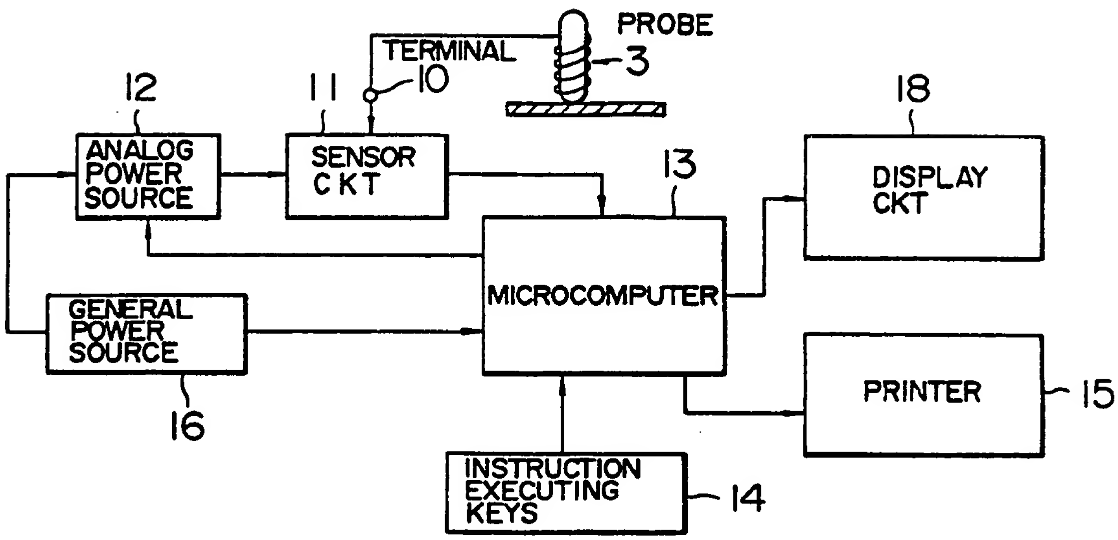

IRON CORE
1
3
PROBE
I
A
4
COIL
2
FILM
5
D
6
IRON MATERIAL

FIG. 2


ΔI₀
22
(MATERIAL A)
C2
CURRENT CHANGE ΔI
21
(MATERIAL B)
C1
FILM THICKNESS
(DISTANCE FROM THE IRON SURFACE) D

F I G. 3


PROBE
TERMINAL
3
10
12
11
18
ANALOG POWER SOURCE
SENSOR CKT
13
DISPLAY CKT
MICROCOMPUTER
GENERAL POWER SOURCE
16
PRINTER
15
INSTRUCTION EXECUTING KEYS
14

F I G. 4

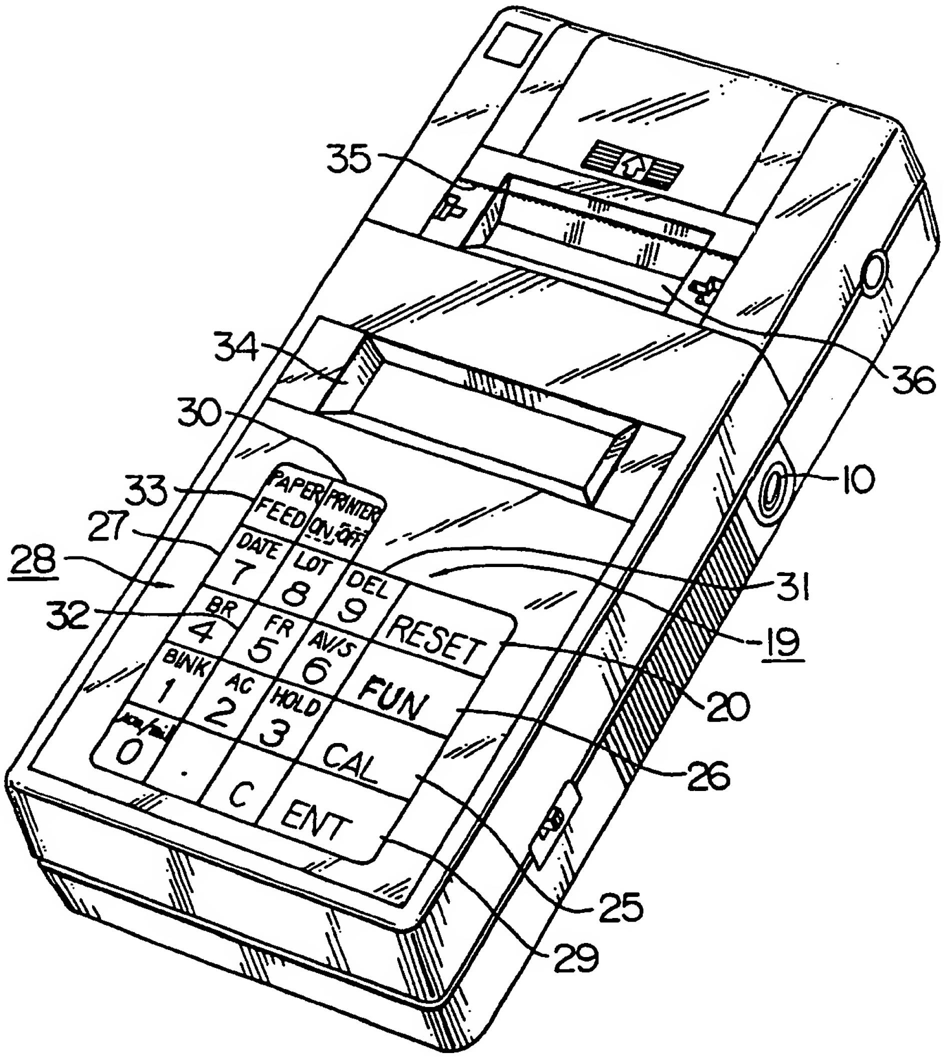

35
34
30
33
27
28
32
36
10
31
19
20
26
25
29
PAPER FEED
PRINTER ON OFF
DATE 7
LOT 8
DEL 9
RESET
BR 4
FR 5
AV/S 6
FUN
BINK 1
AC 2
HOLD 3
CAL
0
.
C
ENT

FIG. 5

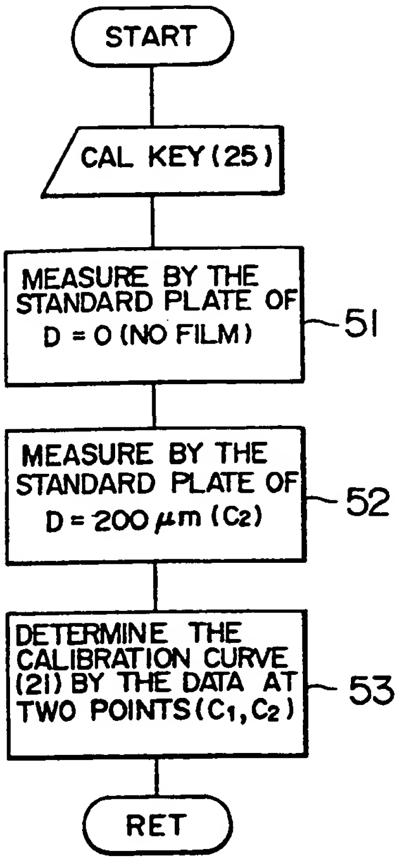


FIG. 6

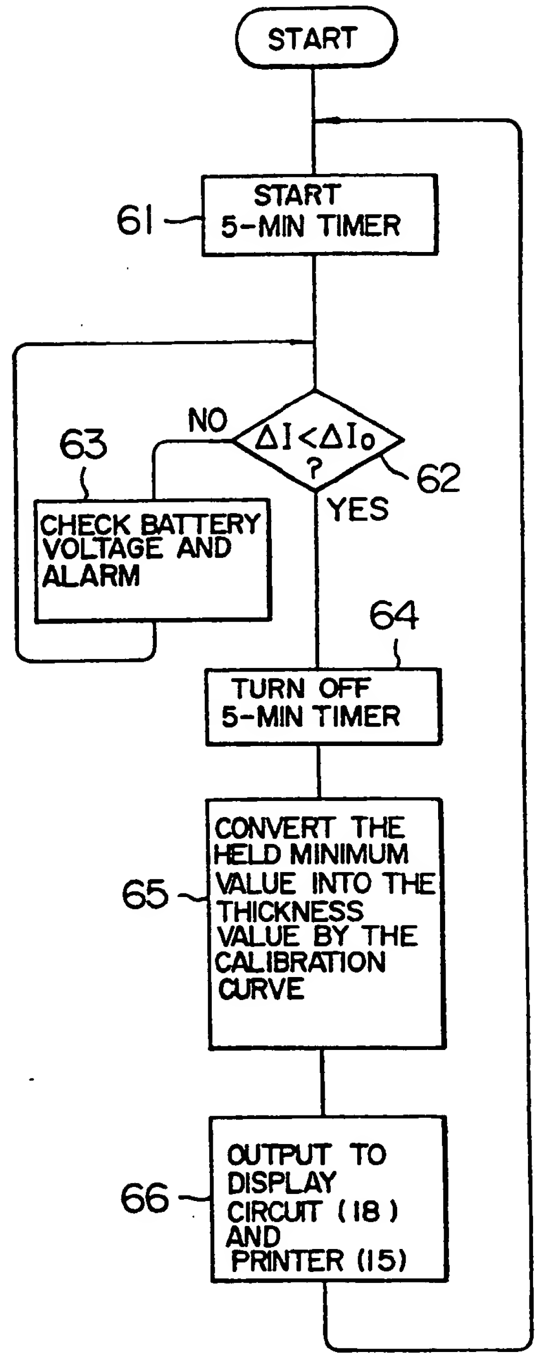


FIG. 7